

2m Interference Reduction System

by Trevor S Day, G3ZYY

HIS CIRCUIT WILL substantially reduce or completely eliminate interference from almost any local source whilst leaving the wanted signal relatively unaffected, even though it may be on the same frequency! Once the unit is adjusted for a particular source of interference, the user is free to operate anywhere in the band without further adjustment.

The design of the circuit limits operation to a small band of frequencies, however it is sufficient to cover the entire two metre band. The principle can also be used at 50 and 70MHz and indeed this unit was first constructed to work at 50MHz in order to remove computer hash. (See issue 28 of the UK Six Metre Group Newsletter).

PRINCIPLE OF OPERATION

THE BLOCK DIAGRAM (Fig 1) shows the method of operation. Both the wanted and interfering signals arrive at pre-amplifier 1 from the main antenna via the antenna switch. The sense antenna, by virtue of its inefficiency at the wanted frequency, picks up predominantly the interfering signal and passes this to pre-amplifier 2. Both preamplifier outputs eventually add in the signal combiner. However, the interfering signal is first changed in phase by 180°. The resultant output of the combiner is the same as the input to pre-amplifier 1 from the main antenna less the interfering signal.

CIRCUIT DESCRIPTION

BOTH PRE-AMPLIFIERS are standard dual gate MOSFET designs, using the 3SK81

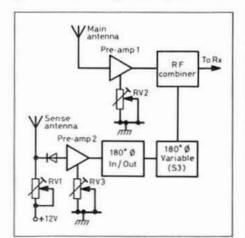


Fig 1: The two signal paths are combined via a phase-shift network.

device as these were to hand (Fig 2). Almost any common dual gate MOSFET will work in this configuration, eg the 40673. RV3 controls the gain of pre-amplifier 2 and is adjustable from the front panel. Its purpose is to match the level of the interfering signal from pre-amplifier 2 to the interfering signal from pre-amplifier 1 at the signal combiner, thus ensuring complete cancellation. RV2 is a preset potentiometer controlling the gain of pre-amplifier 1 in the wanted signal path from the main antenna.

Pre-amplifier 2 feeds its output to a fixed 180° phase inverter (DL1) formed by an electrical half-wavelength of RG174U miniature 50Ω co-axial cable which may be switched in or out of circuit by the diode switch comprising D6, D7, D8 and S2. A further variable 180° phase shift is achieved by S3. This is a half-wavelength of RG174U cable in eleven sections, switched in approximately 16° phase change steps.

The connecting cables from the switch to the PCB should be as short as practically possible (six inches max) as these will introduce additional phase changes. However, these are compensated for by the fine phase control. Fine phase control is achieved by a 1N914 diode acting as a varactor across the input circuit to pre-amplifier 2. The additional capacitance of the diode, controlled by RV1.

alters the input tuning of pre-amplifier 2 but more importantly slightly shifts the phase of the signal arriving at the pre-amplifier. The output of the phase switch and of pre-amplifier 1 are both fed to a signal combiner comprising R8, C14, C15, L5 and L6. This is a 50Ω signal splitter operating in reverse. Its purpose is to add both signals and, as the interfering signal in one path is 180° out of phase with its complement in the other path, the interfering signal is drastically reduced or eliminated completely.

CONSTRUCTION

THE MAIN PCB IS constructed from double-sided glass fibre board; the underside layout is shown in Fig 3. The top side is blank copper. Track widths are not especially critical and the board can easily be marked with a Dalo type pen on the track side and some nail varnish on the reverse. The gate 2 voltage to each pre-amplifier has been derived separately to allow the two 'halves' of the circuit to be separated by screens in order to reduce cross-talk. The screens are constructed from the same double-sided PCB, about 20mm wide and soldered into place prior to mounting the components.

The phase switch is a twelve way rotary switch soldered to a PCB carrier which holds

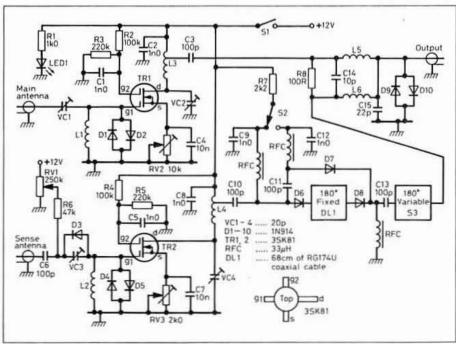


Fig 2: Circuit diagram shows how signals from the two antennas are amplified in a variable gain MOSFET configuration.

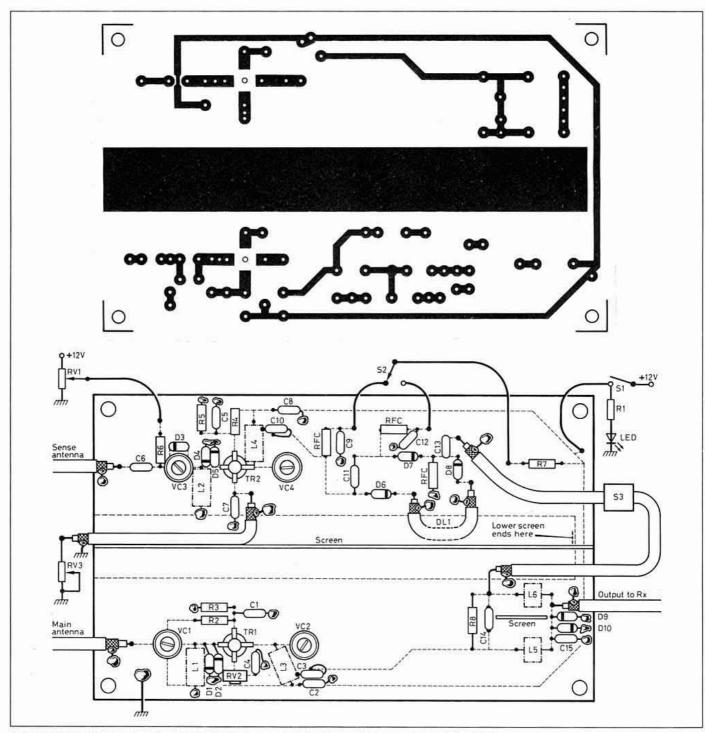


Fig 3: Underside and component layout of the PCB, shown actual size. Track widths are not especially critical.

the eleven loops of RG174U co-ax (Fig 4). The PCB carrier should be fashioned to suit the size of switch used along the lines shown in the diagram. Losses through the switch are not particularly significant as only the amplified interfering signal passes through it. The carrier is made from the same double-sided PCB stock as the main board. When complete, the co-ax loops lie in the same plane as the switch shaft. (See photograph). The fine phase control will compensate for the extra path length through varying sizes of switch; however, a smaller switch is preferred for compactness. Whichever box is used to hold the device, it should be RF tight. A die-cast aluminium box is ideal and will need to be approximately 203x114x64mm. Component values are not especially critical, although the coil dimensions should be adhered to and the components forming the combiner should be as close to those specified as possible. Note that a small screen is also required to separate L5 and L6 in the signal combiner. The fixed 180° phasing line DL1 may be coiled and taped up for compactness.

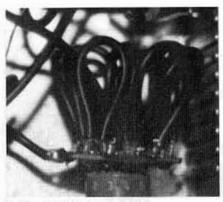
SETTING UP

ADJUSTMENT PRIOR TO use is quite straightforward and requires no test equipment:

a) Power up the unit and connect it between

- the receiver and main antenna, leaving the sense antenna disconnected.
- b) Tune to a weak signal on FM or a carrier on SSB/CW and with the fine phase control at mid position, adjust VC1 and VC2 at pre-amplifier 1 for best signal to noise. Adjust RV2 for optimum signal level at the receiver.
- c) Disconnect the main antenna and connect the sense antenna. With RV3 adjusted for a low 'S' meter reading, adjust VC3 and VC4 in pre-amplifier 2 for maximum signal.
- d) Re-connect the main antenna.

This completes the setting up adjustments.



Details of switched coax loops.

OPERATION

AS WITH MOST electronic devices, operation is simpler to carry out than to describe.

- Tune to the interfering signal; if it is broadband then attempt to find a peak.
- b) Adjust the balance control (RV3) to find a dip in the level of the interfering signal, switching the fixed 180° phasing line in or out as required. It may be a shallow dip, but a dip must be found. If no dip is apparent, then the sense antenna must be adjusted or changed.
- Rotate the phase switch (S3) to find a deep dip in the interfering signal, adjusting

LIMITATIONS

THE OPERATION OF this device relies upon the interfering signal arriving at both antennas in a fixed phase relationship; ie it does not matter what the relative phase difference is as long as it does not change. Additionally, the amplitude of the unwanted signal at each pre-amplifier input must be relatively constant. In other words, if you change your beam heading then the balance of the circuit will be upset and RV3 will need re-adjustment. The other controls should remain unaltered.

Any active device will add noise to the received signal and this one is no exception. The wanted signal to noise ratio may be degraded slightly but the benefits of reducing interference far outweigh this disadvantage. The system will not remove 'DX' interference as the sense antenna will be ineffective at low signal levels. Remember also that the sense antenna may introduce unwanted signals that are not audible on the main antenna (mains wiring noise etc.). If this proves to be the case, then the sense antenna should be moved to a less noisy location.

To achieve useful results, the difference in strength of the interfering signal at both preamplifiers must be able to be compensated for by RV3. The sense antenna must be chosen so that this condition can be met. In essence, understanding the principle of operation will enable best results to be achieved.

COMPONENTS LIST

L1 8t 18SWG 3/16" (4.5mm) id 1/2" (13mm) long

L2 8t 18SWG 3/16" (4.5mm) id 1/2" (13mm) long

8t 18SWG 3/16" (4.5mm) id 1/2" L3 (13mm) long, tap at 1 turn 8t 18SWG 3/16" (4.5mm) id 1/2"

14 (13mm) long, tap at 1 turn

8t 18SWG 1/4" (6.5mm) id 3/4" 15 (19mm) long

8t 18SWG 1/4" (6.5mm) id 3/4" (19mm) long

C9 1nF C1 1nF C10 100pF C2 1nF C3 100pF C11 100pF C4 10nF C12 1nF C13 100pF C5 1nF C6 100pF C14 10pF C15 22pF C7 10nF C8 1nF

VC1,VC2,VC3,VC4 20pF

RFC 33µH x 3

R5 220k R1 1k 100k R2 R6 47k R3 220k R7 2k2 100k **R8 100R** R4 250k lin. RV₁ RV2 10k lin. pre-set.

RV3 2k lin.

68cm RG174U co-ax DL1 braiding to earth plane.

TR1,TR2 3SK81 D1-10 1N914 LED Red or Green

no deep dip is found, then switch in (or out) the fixed 180° phasing line and try again. d) Finally adjust the fine phase control (RV1)

the balance control to maintain the dip. If

for best null, further adjusting the balance if required.

A measure of the effectiveness of the unit can be achieved by switching in and out the fixed 180° phasing line and observing the change in signal level; the effect is quite startling! To achieve optimum results the sense antenna should be remote from the shack as movement of the antenna, or people in the shack, can affect the arrival phase of the interfering signal and make the null unstable. Even if a random short length of wire or whip antenna is used, it should either be outdoors or in the loft and fed to the shack via co-axial cable.

USES

THE ORIGINAL REASON for devising this circuit was to remove computer hash at 50MHz for which it has proved highly successful. The two metre circuit described here was built as an experimental novelty. However it has proved to be most versatile, and the unit will deal effectively with the following situations:

- a) A local packet node or a local amateur desensing your receiver across the 2m
- b) A local amateur with a 'wide' signal (for whatever reason); unlike a notch filter not only is the 'fundamental' signal removed, but also all in-band spurii. This holds true even if the 'wide' signal is caused by your receiver's front-end overload; eg from a contest station on a nearby hilltop.
- c) Your own, or a neighbour's, computer

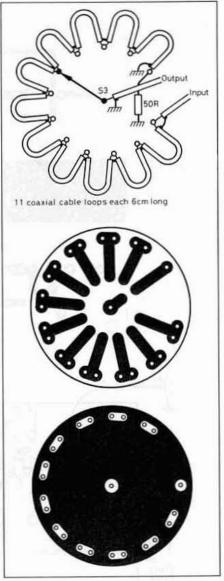


Fig 4: Coarse adjustment of phase uses a 12-way switch, fitted on a double-sided PCB carrier.

generated interference. (Bear in mind that a computer may radiate signals from several sources but only one source can be dealt with at a time).

Next door's persistent central heating system noise.

The most impressive demonstration to date has been a local amateur on FM, many dB over 'S9', transmitting at the same time and on the same frequency as another station at 'S5'. Using two receivers in the shack, one with this unit and one without, both transmissions were heard simultaneously without a trace of interference on either.

CONCLUSION

THE UNIT IS RELATIVELY easy to construct and is simple in concept. For anyone who has ever said "It's that ZYY again; what I need is a ZYY filter", then this is it!

ACKNOWLEDGMENTS

VHF/UHF Manual, G R Jessop, G6JP, (RSGB) ARRL Handbook, (ARRL)